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EFFECTS OF SOIL FERTILITY ON POTATO PLANT DEVELOPMENT IN THE MATANUSKA VALLEY

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INTRODUCTION

Nutrient uptake and physiological development in potato plants have been investigated in major potato growing regions, but comparable studies have not been conducted in high latitude areas such as the potato producing sections of southcentral Alaska. Knowledge of plant development and nutrient partitioning among various plant parts is important both in terms of general understanding of the growth habits of potatoes in a unique environment and for improved management of field production of this crop. Nutrient response data provide a basis for fertilizer application recommendations.

A field study designed to define potato plant development under various fertility regimes was initiated in 1989. Potato plants were intensively sampled through the growing season to determine the effects of nutrient availability on growth processes, to measure growth rates of various plant parts, and to determine the fate of nutrients absorbed by the plant. The results of the effects of soil fertility on potato plant development are presented in this report. Nutrient uptake and partitioning data will be compiled in later publications when laboratory analyses are complete.

MATERIALS AND METHODS

Field plots were established in the spring of 1989 on a Knik silt loam, at the University of Alaska Agricultural and Forestry Experiment Station Matanuska Farm. Initial surface soil (0-6 inch) nutrients were determined by Mehlich 3 extractant. Organic matter was measured by combustion and pH was measured in a 1:1 soil:water suspension. Results of these analyses are reported in Table 1.

Table 1. Mehlich 3 soil test levels prior to fertilization.

pH	Organic Matter (%)	P	K	Ca	Mg
		ppm			
6.05	5.2	67	61	1586	159

Forty plots, each measuring 15 by 40 feet, were arranged in a randomized complete block design, with ten treatments and four replications. Treatments consisted of a non-fertilized check, and three rates of nitrogen (N), phosphorus (P), and potassium (K) in various combinations. Nitrogen was applied as ammonium nitrate (33-0-0), P as triple super phosphate (0-45-0), and K as potassium chloride (0-0-60). The fertilizer treatment rates are indicated in Table 2. The plot area was chisel-plowed on May 10. Fertilizer treatments were broadcast over the soil surface and mechanically tilled to a depth of approximately eight inches with a tractor-mounted rototiller on May 12. Potato seed-pieces (var. Bake-King) were planted on May 19 with a single row Iron Age assist-feed planter, spaced approximately 11 inches apart in the row and covered with two to three inches of packed soil. Rows were three feet apart.

Plots were watered as needed through the growing season. Beginning at tuber initiation, five

Table 2. Fertilizer treatments applied prior to planting.

Treatment Number	N	P	(P_2O_5)	K	(K_2O)
	lbs/acre				
1	0	0	(0)	0	(0)
2	60	105	(240)	200	(240)
3	120	105	(240)	200	(240)
4	240	105	(240)	200	(240)
5	120	53	(120)	200	(240)
6	120	210	(480)	200	(240)
7	120	105	(240)	100	(120)
8	120	105	(240)	400	(480)
9	60	53	(120)	100	(120)
10	240	210	(480)	200	(240)

plants per plot were removed by hand, washed, and separated into above-ground portions (tops), roots, and stolons plus tubers every two weeks until harvest. Each portion was weighed, oven-dried at 150° F until weight loss ceased, then reweighed. Sampling dates were July 6, July 20, August 2, August 17, August 29, and September 13. Each sampling required two to three days with the dates listed representing the first day of each sampling period. On the last sampling date only plant tops were collected by hand. Thirty-five feet of row from each plot was lifted with a mechanical lifter which dug the tubers and dropped them on the soil surface. Tubers were then collected by hand, washed, graded by USDA specifications, and weighed. Dry tuber weight was estimated from specific gravity measured by weighing subsamples of tubers from each plot in both air and water. No root measurements were taken in the last sampling period.

RESULTS AND DISCUSSION

Tops

Production of above-ground potato plant biomass (dry weight) was most limited where no fertilizer was applied and was not affected by additions of N or K above the lowest rates. Addition of 210 lbs P per acre stimulated top growth more than the 53 and 105 lbs P per acre treatments (Figure 1). There was a slight, statistically non-significant increase in above-ground biomass when N application rates were increased (data not shown). Top growth was generally completed by the thirteenth week after planting.

Roots

Root biomass did not change substantially after the first sampling period in the fertilized plots. In the unfertilized check, root biomass increased until the eleventh week after planting. No differences were noted in the root systems produced with various fertilizer treatments. Lack of observed differences in root dry weight as a function of applied fertilizer may be due to the difficulty in accurately collecting plant roots from the soil.

Tubers

For each fertilizer treatment, tuber growth rate was nearly linear from the time of the first sampling at tuber initiation seven weeks after planting until harvest 10 weeks later. Tuber growth was least in the unfertilized check plots but little difference in tuber growth was observed among the other treatments. The effects of P and K application rates on tuber biomass accumulation are shown in Figures 2 and 3. While the highest rates of P and K (210 lbs P per acre and 400 lbs K per acre) increased tuber dry weight slightly, the differences were not statistically significant. Tuber dry weight was statistically unaffected by varying N from 60 to 240 lbs N per acre.

Fresh tuber yields were also lowest in the unfertilized check (Table 3). Increasing N and P above the lowest rates had little effect on fresh yield of either total or US No.1 tubers. Addition of K, however, increased the weight of both total and US No.1 harvested.

Since additional K increased the fresh weight of harvested tubers more than tuber dry weight, it is evident that the amount of water contained in the fresh tubers was altered. This is illustrated by the effect of added K on the specific gravity of fresh tubers. A decrease in specific gravity indicates an increase in the fraction of a tuber comprised of water. Higher rates of K resulted in tubers with depressed specific gravities and therefore elevated water contents. It should be noted that K was applied in the form of KCl which may have a larger effect on tuber specific gravity than other

Table 3. Effects of N, P, and K treatments on potato tuber yield, shatter-cracking, and specific gravity.

Treatment Number	Fertilizer Treatment	Tuber Yield Total	Tuber Yield US No.1	S-C*	Specific Gravity
		cwt/a			
1	None	172	154	0.20	1.102
2	60 lbs N/a	326	305	4.19	1.091
3	120 lbs N/a	328	299	13.55	1.087
4	240 lbs N/a	324	292	17.40	1.084
5	53 lbs P/a	316	300	2.19	1.087
3	105 lbs P/a	328	299	13.55	1.087
6	210 lbs P/a	339	316	7.40	1.088
7	100 lbs K/a	312	286	8.23	1.093
3	200 lbs K/a	328	299	13.55	1.087
8	400 lbs K/a	365	338	11.25	1.085
	LSD 5%	49	51	10.48	0.004

*S-C = shatter-cracked tubers.

K sources such as K_2SO_4 (Laughlin, 1966; Wilcox, 1961). Nitrogen also depressed specific gravity, while P application had no effect on this tuber property.

In addition to changes in specific gravity, there were some differences in the number of tubers which shatter-cracked when harvested (Table 3). Shatter-cracking is caused when a tuber splits or breaks when bruised during mechanical harvest. The statistical reliability of the shatter-crack evaluation is low due to the relatively small number of tubers involved. Application of N at the highest rate (240 lbs per acre) caused an increase in the weight of shatter-cracked tubers when compared to the lowest rate of N application (60 lbs per acre).

SUMMARY

These preliminary data contrast with the most recently published fertilizer guidelines for potato production in the Matanuska Valley. Loynichan et al (1979) recommend application of 75 lbs N per acre, 176 lbs P per acre (400 lbs P_2O_5 per acre), and 166 lbs K per acre (200 lbs K_2O per acre), although most growers apply somewhat more N and less P. More recent guidelines for P fertilization (Michaelson and Ping, 1989) indicate that for a P soil test value of 67 ppm, the level we observed at planting, 109 lbs P per acre (248 lbs P_2O_5 per acre) is recommended for maximum potato production. We observed top yields with lower P and higher K rates than those recommended. It should be noted, however, that the soil test K levels at planting were low at 61 ppm. Growers in the Matanuska Valley are unlikely to observe soil test K levels this low in previously cropped areas.

The following remarks are derived from data collected in this initial year of study only:

- Marketable tuber yield was maximized by application of as little as 53 lbs P per acre and 60 lbs N per acre.
- Fresh tuber yield was greatest when applied K was 400 lbs per acre, the highest rate in the experiment.
- High rates of P fertilizer increased top growth without affecting tuber yield or other measured growth paramenters.
- The amount of shatter-cracking increased as the rate of N application increased.
- Increasing rates of either N or K depressed tuber specific gravity.

Accurate fertilizer recommendations are based on soil test correlation values. Recommendations will continue to reflect the impact of additional data to be collected in coming years.

Figure 1. Effect of phosphorus on dry weight of potato plant tops.

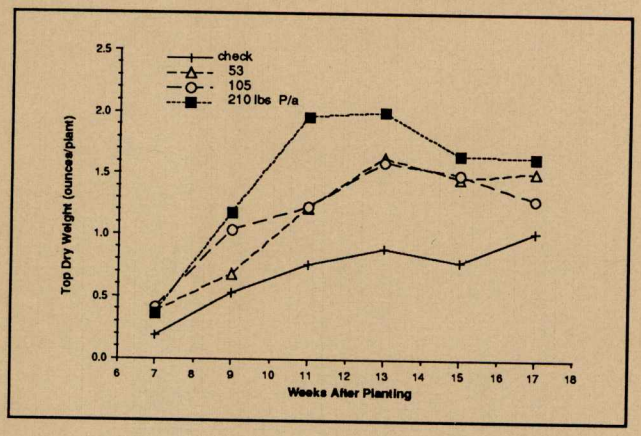

Figure 2. Effect of phosphorus on dry weight of potato tubers.

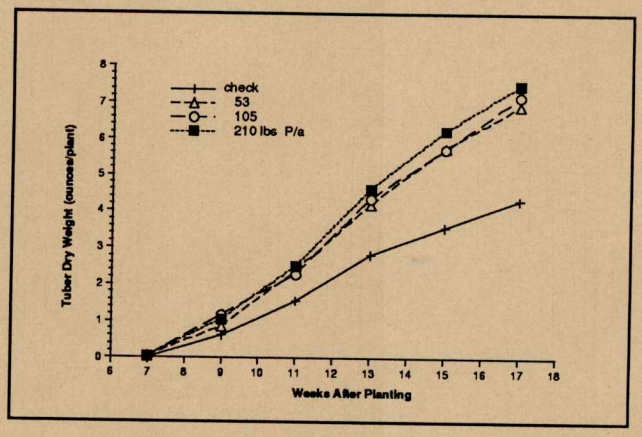

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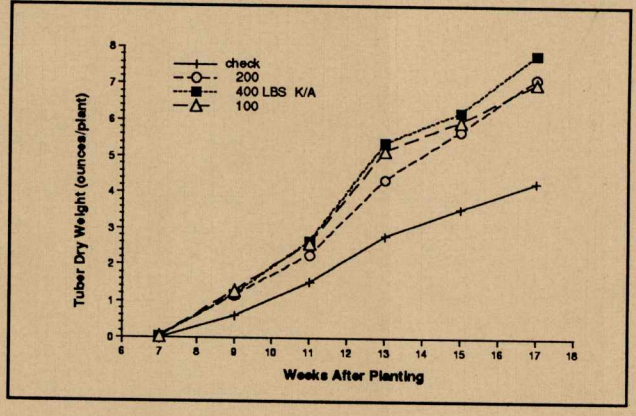
Figure 3. Effect of potassium on dry weight of potato tubers.



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